

Hazardous Waste: Any solid, liquid, or containerized gas that can catch fire easily, is corrosive to skin tissue or metals, is unstable and can explode or release toxic fumes, or has harmful concentrations of one or more toxic materials that can leach out

A waste that due to its (intrinsic) chemical or other properties poses a risk to the environment and/or human health.

Hazardous Waste Global Context

- BASEL Convention on the control of Trans boundary movement of hazardous waste and their disposal;
 - Adopted: 22 March 1989, Nepal Accession(a) 15 Oct., 1996
 - Entered into force: 05 May 1992 , Nepal: 13 Jan., 1997
- ☐ A growing Threat to Human and Environment
- ☐ Risk of Damage to Human and Environment
- ☐ Protection of Human and Environment and Reduction on Production
- ☐ Anywhere any time ensure safety in regard of human health and environment during movement and disposal
- ☐ Generator has major duty and any Sovereign state has right to reject or ban entry into its territory
- ☐ Recognized Developing Country context (capacity assessment, Promote Transfer of Technology)
- ☐ As far as compatible shall dispose at the place of origin
- ☐ States are responsible for the fulfillment of their international obligations and are liable in accordance with international law,
- ☐ Need to continue the development and implementation of low-waste technologies, recycling options, good house-keeping, and management systems ;
- ☐ Reduction in movement (stringent control of illegal movement)

Annex-1 Basel (CATEGORIES OF WASTES TO BE CONTROLLED)

Y1	Clinical wastes from medical care in hospitals, medical centers and clinics
Y2	Wastes from the production and preparation of pharmaceutical products
Y3	Waste pharmaceuticals, drugs and medicines
Y4	Wastes from the production, formulation and use of biocides and phytopharmaceuticals
Y5	Wastes from the manufacture, formulation and use of wood preserving chemicals
Y6	Wastes from the production, formulation and use of organic solvents
Y7	Wastes from heat treatment and tempering operations containing cyanides
Y8	Waste mineral oils unfit for their originally intended use
Y9	Waste oils/water, hydrocarbons/water mixtures, emulsions
Y10	Waste substances and articles containing or contaminated with polychlorinated biphenyls (PCBs) and/or polychlorinated terphenyls (PCTs) and/or polybrominated biphenyls (PBBs)
Y11	Waste tarry residues arising from refining, distillation and any pyrolytic treatment
Y12	Wastes from production, formulation and use of inks, dyes, pigments, paints, lacquers, varnish
Y13	Wastes from production, formulation and use of resins, latex, plasticizers, glues/adhesives
Y14	Waste chemical substances arising from research and development or teaching activities which are not identified and/or are new and whose effects on man and/or the environment are not known
Y15	Wastes of an explosive nature not subject to other legislation

Annex-1 Basel

- [Y16]Waste from production formulation and use of photographic chemicals and processing materials
- [Y17]Wastes resulting from surface treatment of metals and plastics
- [Y18]Residues arising from industrial waste disposal operations
- **Wastes having as constituents:**
- Metal carbonyls
- Metals and compounds of Be, Hexavalent Cr, Cu, Pb, Zn, As, Se, Cd, Sb (Antimony),Te (Tellerium), Hg, TL (Thallium)
- Inorganic Fluorine (except CaF), CN-
- Acid, Base
- Asbestos (Dust and Fibres)
- Organic Phosphorous, CN, Phenols, Ethers, Organic Solvents
- polychlorinated dibenzo-furan, polychlorinated dibenzo-p-dioxin
- Organohalogen compounds
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CATEGORIES OF WASTES REQUIRING SPECIAL CONSIDERATION

Y46	Wastes collected from households
Y47	Residues arising from the incineration of household wastes
Y48^{6,7}	Plastic waste, including mixtures of such waste, with the exception of the following: • Plastic waste that is hazardous waste pursuant to paragraph 1 (a) of Article 1⁸ • Plastic waste listed below, provided it is destined for recycling⁹ in an environmentally sound manner and almost free from contamination and other types of wastes:¹⁰ - Plastic waste almost exclusively¹¹ consisting of one non-halogenated polymer, including but not limited to the following polymers: ▪ Polyethylene (PE) ▪ Polypropylene (PP) ▪ Polystyrene (PS) ▪ Acrylonitrile butadiene styrene (ABS) ▪ Polyethylene terephthalate (PET) ▪ Polycarbonates (PC) ▪ Polyethers

Annex-II Basel [CATEGORIES OF WASTES REQUIRING SPECIAL CONSIDERATION]

- Plastic waste almost exclusively¹¹ consisting of one cured resin or condensation product, including but not limited to the following resins:
 - Urea formaldehyde resins
 - Phenol formaldehyde resins
 - Melamine formaldehyde resins
 - Epoxy resins
 - Alkyd resins
- Plastic waste almost exclusively¹¹ consisting of one of the following fluorinated polymers:¹²
 - Perfluoroethylene/propylene (FEP)
 - Perfluoroalkoxy alkanes:
 - Tetrafluoroethylene/perfluoroalkyl vinyl ether (PFA)
 - Tetrafluoroethylene/perfluoromethyl vinyl ether (MFA)
 - Polyvinylfluoride (PVF)
 - Polyvinylidene fluoride (PVDF)
- Mixtures of plastic waste, consisting of polyethylene (PE), polypropylene (PP) and/or polyethylene terephthalate (PET), provided they are destined for separate recycling¹³ of each material and in an environmentally sound manner and almost free from contamination and other types of wastes.¹⁰

BASEL ANNEX IV-DISPOSAL OPERATIONS

- **A. Operations which do not lead to the possibility of resource recovery, recycling, reclamation, direct re-use or alternative uses**

D1	Deposit into or onto land, (e.g., landfill, etc.)
D2	Land treatment, (e.g., biodegradation of liquid or sludgy discards in soils, etc.)
D3	Deep injection, (e.g., injection of pumpable discards into wells, salt domes of naturally occurring repositories, etc.)
D4	Surface impoundment, (e.g., placement of liquid or sludge discards into pits, ponds or lagoons, etc.)
D5	Specially engineered landfill, (e.g., placement into lined discrete cells which are capped and isolated from one another and the environment, etc.)
D6	Release into a water body except seas/oceans
D7	Release into seas/oceans including sea-bed insertion
D8	Biological treatment not specified elsewhere in this Annex which results in final compounds or mixtures which are discarded by means of any of the operations in Section A
D9	Physico chemical treatment not specified elsewhere in this Annex which results in final compounds or mixtures which are discarded by means of any of the operations in Section A, (e.g., evaporation, drying, calcination, neutralization, precipitation, etc.)
D10	Incineration on land
D11	Incineration at sea
D12	Permanent storage (e.g., emplacement of containers in a mine, etc.)
D13	Blending or mixing prior to submission to any of the operations in Section A
D14	Repackaging prior to submission to any of the operations in Section A
D15	Storage pending any of the operations in Section A

BASEL ANNEX IV-DISPOSAL OPERATIONS

B. Operations which may lead to resource recovery, recycling reclamation, direct re-use or alternative uses

R1	Use as a fuel (other than in direct incineration) or other means to generate energy
R2	Solvent reclamation/regeneration
R3	Recycling/reclamation of organic substances which are not used as solvents
R4	Recycling/reclamation of metals and metal compounds
R5	Recycling/reclamation of other inorganic materials
R6	Regeneration of acids or bases
R7	Recovery of components used for pollution abatement
R8	Recovery of components from catalysts
R9	Used oil re-refining or other reuses of previously used oil
R10	Land treatment resulting in benefit to agriculture or ecological improvement
R11	Uses of residual materials obtained from any of the operations numbered R1-R10
R12	Exchange of wastes for submission to any of the operations numbered R1-R11
R13	Accumulation of material intended for any operation in Section B

Other Global and Regional Measures

- Declaration of the United Nations Conference on the Human Environment (Stockholm, 1972),
- The Cairo Guidelines and Principles for the Environmentally Sound Management of Hazardous Wastes adopted by the Governing Council of the United Nations Environment Programme (UNEP) by decision 14/30 of 17 June 1987,
- The Recommendations of the United Nations Committee of Experts on the Transport of Dangerous Goods (formulated in 1957 and updated biennially),
- Relevant recommendations, declarations, instruments and regulations adopted within the United Nations system and the work and studies done within other international and regional organizations
- World Charter for Nature adopted by the General Assembly of the United Nations at its thirty-seventh session (1982) as the rule of ethics in respect of the protection of the human environment and the conservation of natural resources,

Nepalese Context

- The inventory of hazardous waste (July 2008)_ADB-TA for the three important sectors namely the industry, hospital and automobile workshops showed that:
 - the estimated annual quantity of Hazardous Wastes for the year 2006/07 were 5,051 M/T of solid, 6,404,872 cu. m. of liquid from 12 important sectors of industries;
 - 4,195 M/T of Healthcare Risk waste; and
 - 3,465 M/T of solid and 157,757 cu. m. of liquid from the automobile workshops. The results of the study also show that the generations of above wastes are steadily increasing.

“Explosive”: Wastes which are capable by chemical reaction of producing gas at such a temperature and pressure and at such a speed as to cause damage to the surroundings. Pyrotechnic wastes, explosive organic peroxide wastes and explosive self-reactive wastes are included

“Oxidising”: Wastes which may, generally by providing oxygen, cause or contribute to the combustion of other materials

“Sensitising”:¹⁴ Wastes which contain one or more substances known to cause sensitising effects to the skin or the respiratory organs

“Ecotoxic”: Wastes which present or may present immediate or delayed risks for one or more sectors of the environment.

“Yielding another substance”: Wastes capable of exhibiting a hazardous property listed above not directly displayed by the original waste

“Flammable”:

- Flammable liquid wastes: liquid wastes having a flash point below 60°C or waste gas oil, diesel and light heating oils having a flash point $> 55^{\circ}\text{C}$ and $\leq 75^{\circ}\text{C}$
- flammable pyrophoric liquid and solid wastes: solid or liquid wastes which, even in small quantities, are liable to ignite within five minutes after coming into contact with air
- flammable solid wastes: solid wastes which are readily combustible or may cause or contribute to fire through friction
- flammable gaseous wastes: gaseous wastes which are flammable in air at 20°C and a standard pressure of 101.3 kPa
- water reactive wastes: wastes which, in contact with water, emit flammable gases in dangerous quantities
- other flammable wastes: flammable aerosols, flammable self-heating wastes, flammable organic peroxides and flammable self-reactive wastes.

“Irritant – Skin irritation and eye damage”: Wastes which on application can cause skin irritation or damage to the eye

“Specific Target Organ Toxicity (STOT)/ Aspiration”: Wastes which can cause specific target organ toxicity either from a single or repeated exposure, or which cause acute toxic effects following aspiration

“Acute Toxicity”: Wastes that can cause acute toxic effects following oral or dermal administration, or inhalation exposure

“Carcinogenic”: Wastes which induce cancer or increase its incidence

“Corrosive”: Wastes which on application can cause skin corrosion

“Infectious”: Wastes containing viable micro-organisms or their toxins which are known or reliably believed to cause disease in man or other living organisms

“Toxic for reproduction”: Wastes which have adverse effects on sexual function and fertility in adult males and females, as well as developmental toxicity in the offspring

“Mutagenic”: Wastes which may cause a mutation, that is a permanent change in the amount or structure of the genetic material in a cell

“Release of an acute toxic gas”: Wastes which release acute toxic gases (Acute Tox.1, 2 or 3) in contact with water or an acid







Type of hazard	Unicode glyph	Unicode	Image
Generic caution		U+26A0	
Poison		U+2620	
Ionizing radiation		U+2622	
Ionizing radiation – high-level source			
Non-ionizing radiation			
Biological hazard		U+2623	
Carcinogen			
High voltage		U+26A1	
Laser hazard			

Hazardous Waste

- Waste has any of the following characteristics (the Basel Convention)
 - Explosive
 - Flammable Liquids/Solids
 - Poisonous
 - Toxic
 - Ecotoxic
 - Infectious Substances.
- Wastes that belong to any category contained in Annex I to the [Basel Convention \(link is external\)](#), unless they do not possess any of the hazardous characteristics contained in Annex III. Wastes in Annex I include:
 - Clinical wastes;
 - Waste oils/water, hydrocarbons/water mixtures, emulsions;
 - Wastes from the production, formulation and use of resins, latex, plasticizers, glues/adhesives;
 - Wastes resulting from surface treatment of metals and plastics;
 - Residues arising from industrial waste disposal operations; and
 - Wastes which contain certain compounds such as: copper, zinc, cadmium, mercury, lead and asbestos.
- Household waste; or
- Residues arising from the incineration of household waste.
- Copies of Annex 1 and Annex III to the Basel Convention can be found in the *Hazardous Waste (Regulation of Exports and Imports) Act 1989*.

Hazardous Waste

- Hazardous waste-United States, Thailand
- Special waste- Germany;
- Scheduled waste –Malaysia;
- Dangerous goods-Canada;
- bib3 waste-Indonesia;
- Chemical waste-Hong Kong;
- Waste chemicals-Denmark;

Hazardous Waste

- US Resource Conservation and Recovery Act (RCRA)-
 - Statutory Definition: A solid waste, or combination of solid waste, which because of its quantity, concentration, or physical, chemical, or infectious characteristics may (a) cause, or significantly contribute to, an increase in mortality or an increase in serious irreversible, or incapacitating reversible, illness; or (b) pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, or disposed of, or otherwise managed.

- Regulatory Definition:

(1)By listing certain specific wastes as hazardous:

- is a narrative description of a specific type of waste that is considered dangerous enough to warrant regulation. Any waste fitting that narrative listing description is considered hazardous, regardless of its chemical composition or any other potential variable.

(2)By identifying characteristics which, when present in a waste, make it hazardous.



Characteristics of Hazardous Waste

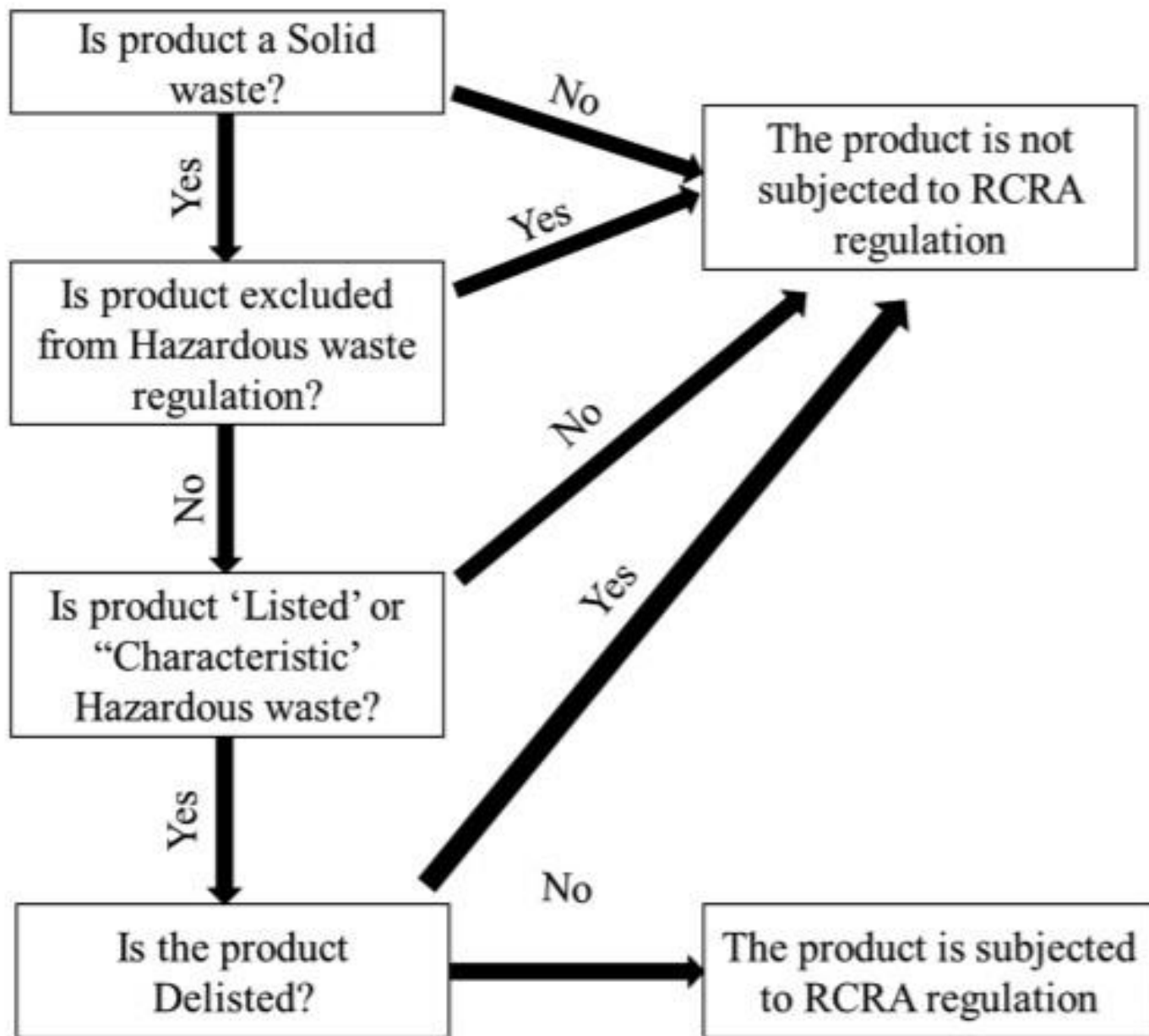
- Characteristics which, when present in a waste, can cause death or illness in humans or ecological damage.
- **Ignitability:** readily catch fire and sustain combustion.
 - paints, cleaners, wood, paper
- **Corrosivity:** acidic or alkaline (basic) wastes which can readily corrode or dissolve flesh, metal, or other materials. (a pH range of 2 through 12.5.)
 - Sulfuric acid from automotive batteries
- **Reactivity:**
 - Explode or violently react when exposed to water, when heated, or under normal handling conditions
 - can create toxic fumes or gases when exposed to water or under normal handling conditions
 - generates toxic levels of sulfide or cyanide gas when exposed to a pH range of 2 through 12.5.
 - Discarded munitions or explosives.
- **Toxicity:** Leachates contaminating drinking water supply

Listed Hazardous Waste (Identification)

- Once a waste matches a listing description, it is forever a listed hazardous waste, regardless of how it is mixed, treated, or otherwise changed. Furthermore, any material that comes in contact with the listed waste will also be considered listed, regardless of its chemical composition.
- **Mixture Rules:** Significant amount of hazardous waste mixed with non-hazardous waste
- **Derived-from rules:** ash produced by burning a listed hazardous waste bears that same waste code and regulatory status as the original listed waste, regardless of the ash's actual properties.

Hazardous Waste-Identification

- Correct identification and subsequent classification are essential to ensure that the collection, transportation, storage, and treatment of waste and its proper disposal are carried out in a manner that not only protects human health but also provides protection for the environment, and in compliance with legal requirements.
- Correct classification depends mostly on correct identification



Biomedical Waste

Any waste material generated during diagnosis, treatment and immunization of human being and animal with potential health and environmental risk.

Hospital waste relate to all waste generated, discarded and not intended for further use

Hg, Ag, Disinfectants, Pesticides

Classification of Biomedical Waste

Category	Waste Content	Components
Category No. 1	Human Anatomical Waste	Human tissues, organs, body parts
Category No. 2	Animal Waste	Animal tissues, organs, body parts carcasses, bleeding parts, fluid, blood and experimental animals used in research, waste generated by veterinary hospitals/colleges, discharge from hospitals, animal and houses
Category No 3	Microbiology & Biotechnology Waste	Wastes from laboratory cultures, stocks or specimens of micro- organisms, live or attenuated vaccines, human and animal cell culture used in research, infectious agents and industrial laboratories, wastes from production of biologicals, from research toxins, dishes and devices used for transfer of cultures

Classification of Biomedical Waste

Category No. 4	Waste sharps	Needles, syringes, scalpels, blades, glass, etc. that may cause puncture and cuts. It includes both used and unused sharps
Category No. 5	Discarded Medicines and Cytotoxic drugs	Wastes comprising of outdated, contaminated and discarded medicines
Category No. 6	Solid Waste	Items contaminated with blood, and body fluids including cotton, dressings, soiled plaster casts, lines, beddings, other material contaminated with blood
Category No. 7	Solid Waste	Wastes generated from disposable items other than the waste sharps such as tubings, catheters, intravenous sets, etc.
Category No. 8	Liquid Waste	Waste generated from laboratory and washing, cleaning, house-keeping and disinfecting activities
Category No. 9	Incineration Ash	Ash from incineration of any biomedical waste
Category No. 10	Chemical Waste	Chemicals used in production of biologicals, chemicals used in disinfection, as insecticides, etc.

Waste Minimization

1. Source reduction

- Purchasing reduction: selection of supplies that are less wasteful and less hazardous
- Use of physical rather than chemical cleaning methods (steam disinfection in place of chemical disinfection)
- Prevention of wastage of products in nursing and cleaning activities

2. Stock management of chemical and pharmaceutical products

- Frequent ordering of small quantities rather than ordering large amount at one time
- Use of oldest batch of product first
- Use of all the contents of the container
- Checking out the expiry dates of all the products at the time of delivery

Method of Treatments of HCW

Category	Waste Content	Method of treatment and disposal
Category No. 1	Human Anatomical Waste	Incineration /deep burial
Category No. 2	Animal Waste	Incineration /deep burial
Category No 3	Microbiology & Biotechnology Waste	Local autoclaving/ microwaving/ incineration
Category No. 4	Waste sharps	Disinfections/chemical treatment/autoclaving/microwaving and mutilation shredding
Category No. 5	Discarded Medicines and Cytotoxic drugs	Incineration/destruction & drugs disposal in secured landfills
Category No. 6	Solid Waste	Incineration, autoclaving/ microwaving
Category No. 7	Solid Waste	Disinfections chemical treatment/autoclaving/microwaving and mutilation shredding
Category No. 8	Liquid Waste	Disinfections by chemical treatment and discharge into drains
Category No. 9	Incineration Ash	Disposal in municipal landfill
Category No. 10	Chemical Waste	Chemical treatment and discharges into drains

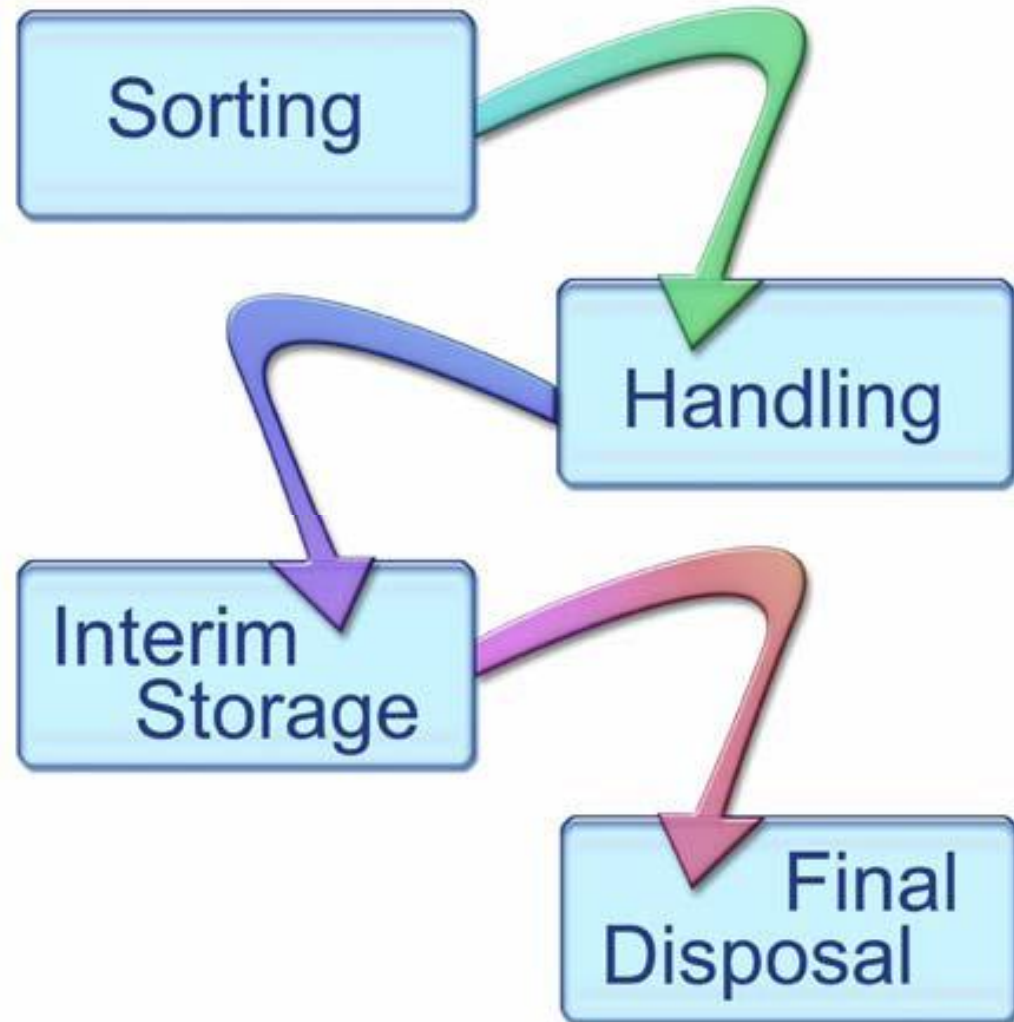
Treatment methods	Advantages	Disadvantages
Incineration	- Reduction of waste volume and weight - Acceptability for all waste types - Heat recovery potential	- Public opposition, larger space and footprint required - High investment and operation cost - Formation of dioxins and furans linked to serious health problems including cancer - High maintenance, testing and repair cost - Vulnerability to future stringent emissions standards
Autoclave Disinfection	- Encourages reuse and recycling - Commercially available - Low investment and operating cost - Easy to operate - Creation of residue that is less hazardous than incineration	- Inability to change waste volume and waste appearance - Lack of suitability for some waste types <i>e.g. low level radiation, toxic contaminant</i> - Production of uncharacterized air emissions and odor problems
Microwave Disinfection	- Significant volume reduction - Absence of liquid discharges	- High investment cost and increased waste weight - Lack of suitability for some waste types - Potential to expose workers to contaminated shredder - Production of uncharacterized air emissions
Chemical Disinfection	- Significant waste volume reduction - Ability to make waste unrecognizable and easy to use - Waste deodorization - No combustion by-products	- Possible toxic by-products in wastewater - Lack of suitability for some waste types - Production of uncharacterized air emissions - Need for chemical storage and use
Plasma pyrolysis	Suitable for all types of waste and results in reductions up to 80-90% in volume and in weight	- Suitable for very large hospitals and regional treatment facilities - Still at the demonstration scale

Waste Management

Mediacal waste management means the management of waste produced by hospitals using such techniques that will help to check the spread of diseases through it.

Steps of waste management:

- (1) Waste segregation/Sorting
- (2) Waste collection
- (3) Waste Transportation
- (4) Waste Storage
- (5) Waste Treatment & Disposal



Steps of Waste management:

(1) Waste segregation:

- Practice of classifying waste & placing it into the appropriate waste container immediately after the waste is generated.
- segregation at source is the most important activity for an effective medical waste management.
- Effective segregation will reduce costs, promote recycling and protect the health and safety of all.
- Waste should be segregated into different colour coded containers according to biomedical rules.

Red: Sharps eg. Needles, syringes, blades

Yellow: Pathological Waste

Green: General Biodegradable waste such as food waste , paper

Blue: Non-biodegradable waste such as unbroken glass bottle, plastic paper, rubber (Recyclable)

Brown: Gloves, Plastic pipes

Waste segregation (contd.)

- Every health care institution should segregate their waste at the source that is at ward side, operation theater, Laboratory or any other room in the hospital where waste is generated into three categories viz, sharps, hazardous and general.
- Needs to be some standard practices for all institutions and should be made mandatory.

Waste Collection

- Waste should be collected at least daily, but more often if necessary.
- Sanitary staff and sweepers shall wear protective clothing at all the times including face masking, industrial aprons, leg protectors, industrial boots and gloves.
- Collection must be in colour coded containers.

Waste Transportation

- For in-site transportation, the waste collected trolley shall be free of sharp edges, easy to load, unload and clean. The trolley shall be cleaned regularly.
- Waste should be transported during low patients flow times.
- Yellow container and Green container general waste shall be collected on separate trolleys.
- The collected waste shall not be left even temporarily anywhere other than the designated central storage facility.
- All vehicles are decontaminated, cleaned after used.

Storage (Temporary)

- Storage of infectious waste should be organized in specific restricted areas. It should be located within health care institution premises close to incinerator, if installed, but away from food storage or food preparation area.
- Easy accessible to collection vehicles.
- The maximum time of storing should not exceed 24h. Mark the storage areas with the biohazard symbol.



Exclusively allocated closed carts should be used to transport wastes. Since medical waste poses a serious health threat to the community:

- Never store medical waste in open containers
- Never throw waste into an open pile.
- Waste should be stored in containers with lids to minimize the potential for insect, rodent, or other animal infestation, and to minimize the smell.

Waste Treatment & Disposal Options

Treatment

- Incineration
- Autoclaving
- Microwaving
- Encapsulation
- Inertization
- Needle Destroyer
- Chemical treatment

Final Disposal:

- Waste Burial
- Cemented Sharp pit
- Sanitary Landfilling

Waste Treatment

- Treatment modifies the characteristics of the waste.
- Treatment of wastes mainly aims
 - at reducing direct exposure less dangerous to humans,
 - at recovering recyclable materials, and
 - at protecting the environment.

The main aim is

- to disinfect infectious waste
- to destroy disposable medical devices, in particular used syringe needles, which should not be reused, or at least to render them inaccessible.

Treatment (contd.)

Incineration: multiple hearth, rotary kiln and controlled air type.



Incinerating is the best option for solid waste disposal, since the high temperature destroys microorganisms and reduces the amount of waste.

Incineration-(contd.)

Combustible waste turned to ash at temps $>800^{\circ}\text{C}$

- Reduces volume and weight (90%)
- Residues are transferred to final disposal site
- Treatment efficiency depends on incineration temperature and type of incinerator
- Not all wastes can be incinerated
- Costs vary greatly according to type of incinerator
- Produces combustion gases

Do not Incinerate

Do not incinerate the following:

- Plastics especially halogenated plastics (e.g. PVC-dioxins furans)
 - Pressurized gas containers
 - Large amounts of reactive chemical waste
 - Radioactive waste
 - Silver salts or radiographic waste
 - Mercury or cadmium (vapour to atmosphere)
 - heavy metals
-
- 70% of the incinerators were found not working properly as planned due to the lack of skilled manpower, spare parts, high fuel consumption, cultural and public objection and lack of management commitment.
 - In Rural and Semi-urban areas-drum incinerator, pit burning, earthen pit disposal and open burning
 - Dumping or throwing waste on the back yard, ditches, rivers, open field, corners of hospital buildings, nearby ponds or anywhere around the premises.
 - Use of municipal waste container. About 60% of the big hospitals in different parts of the country are using municipal waste disposal system for final disposal of the HCW. Bhatta, 2013

Low Temperature burning

- $< 400^{\circ}\text{C}$
- Open air burning of waste in pits, drums, open - brick enclosures on the ground, single chamber incinerator.
- Performance: 100 to 200 kg / day
- Waste residues and ashes are buried.
- Purchase price of single chamber incinerator: up to US\$1,000

Advantages:

- Reduction in waste volume and weight
- No need for highly trained operators

Disadvantages:

- May require fuel.
- Incomplete combustion
- May not completely sterilize
- Potential for needle stick injuries since needles are not destroyed

Disadvantages:

- May require fuel or dry waste for start up and maintenance or high temperatures
- Possible emission of toxic emissions (i.e. heavy metals, dioxins, furans, fly ash) poses a threat to health
- Production of hazardous ash containing leachable metals, dioxins and furans may pollute soil and water
- Requires trained personnel to operate
- Potential for needle stick injuries since some needles may not be destroyed

High Temperature burning ($> 1000\text{C}^{\circ}$)

- 50 kg to 500 kg / hour
- Purchase price of incinerator: US\$50,000-100,000
- Running costs: Fuel

Advantages:

- Complete combustion and sterilization of used injection equipment
- Reduced toxic emissions
- Greatly reduces volume of waste

Disadvantages:

- Expensive to build, operate and maintain
- Requires electricity, fuel and trained personnel to operate
- Possible emission of toxic emissions (i.e. heavy metals, dioxins, furans, fly ash) poses a threat to health and violate environmental health unless pollution control devices are installed
- Production of hazardous ash containing leachable metals, dioxins and furans may pollute soil and water

Pressure Regulating Device

Pressure Gauge

Safety Valve

Autoclave Lid

Handles

Autoclave Body

Steam Release Valve

Vacuum Release Valve

Outer Stand



Autoclaving

- Waste is added to a large autoclave where a combination of heat and pressure sterilizes the waste. the effective inactivation of all vegetative micro-organisms and
- Most bacterial spores in a small amount of waste (about 5–8kg) requires a 60 minute cycle at 121°C (minimum) and 1 bar (100kPa); this allows for full steam penetration of the waste material (WHO, 1999);
- the effective penetration of steam and moist heat depends on many factors including time, temperature, pressure, load size, stacking, configuration and packing density, types and integrity of bags or containers used, physical properties of the materials in the waste (such as bulk density, heat capacity and thermal conductivity), amount of residual air and the moisture content in the waste.

Various commercial models are available. In some countries locally made autoclaves are available.

Autoclaving (contd.)

Sterilizes many types of waste such as used injection equipment

- Low adverse environmental impact

Disadvantages:

- Purchase price: US\$500-50,000
- Requires electricity
- Requires well-trained staff for operation and maintenance
- May emit volatile organics in steam during depressurisation and opening of chamber. If hazardous chemicals such as phenol, or mercury are in the waste, these toxic contaminants are released into the air.
- Not suitable for all waste types
- Waste appearance unchanged, Waste weight unchanged
- If the technology does not include a way of drying the waste, the resulting treated waste will be heavier because of condensed steam.

Encapsulation

- A process in which full safety boxes or disinfected needles are placed within high-density plastic containers or metal drums.
- When containers are three quarters filled with sharps, pharmaceuticals and chemical waste, an immobilizing agent such as plastic foam, bituminous sand, cement mortar or clay is poured into it. Material is allowed to be dried and the container is sealed and disposed safely.
- Then containers are sealed and disposed of in landfill sites or waste burial pits.
- Performance: About 3000 needle-syringes in a 200 l drum

Weakness:

- Requires space availability
- No volume reduction
- Does not disinfect waste
- Potential soil and water pollution

Inertization

- Mixing of waste with cement before disposal in order to minimize the risk of leakage of toxic substances contained in the waste. 65% waste, 15% lime, 15% cement and 5% water. The formed mixture is allowed to set into cubes or pellets and then these are transported to suitable storage site.
- suitable disposal method for the pharmaceuticals and incinerated ash with heavy metal content. (WHO, 1999)
 - Simple
 - May be used for pharmaceutical waste
 - No atmospheric pollution (non burn technique)
 - Not applicable to infectious health care waste

Needle remover

- The used needle is inserted into a device which cuts or pulls the needle off from the syringe.
- Purchase price: US\$2-80
- Blade life: 200,000 cuts

Advantages:

- Prevents needle re-use
- Inexpensive models available (some can be made locally)
- Plastic syringes can be recycled after disinfection
- Easy to operate

Disadvantages

- Splash back of bodily fluids may pose a significant risk to operator and contaminate working areas
- Needles and syringes are still infectious

Chemical treatment

- Aldehydes, chlorine compounds, phenolic compounds are added to HCW to kill or inactivate pathogens. Treatment of wastes with chemical disinfectants e.g. bleach (sodium hypochlorite 1-5% solution). acid hydrolysis followed by alkaline hydrolysis; reduction using zinc powder, degradation using 30% hydrogen peroxide; and destruction using heated alkali.
- Most suitable in treating blood, urine, stools and sewage.

Advantages:

- Inexpensive
- Simple
- Relatively inexpensive
- Disinfectants widely available

Disadvantages:

- Disinfectants may be corrosive and need to be handled safely
- No waste volume reduction
- Environmental health concerns when disinfectants are disposed of

Waste Disposal

- Disposal refers to the final placement of treated waste, using a sanitary landfill or any other environmentally acceptable method of final storage appropriate to the local conditions.

Waste Burial

- the pit should be 2-5 m deep and 1-2 m wide. The bottom of the pit should be at least 2 m above the water table. After each waste load, it should be covered with a 10–30 cm thick soil/lime layer
- Pit sides covered with a low permeability material, covered and fenced. When the level of the waste reaches 30 to 50 cm to the surface of the ground, fill the pit with dirt, seal with concrete and dig another pit.

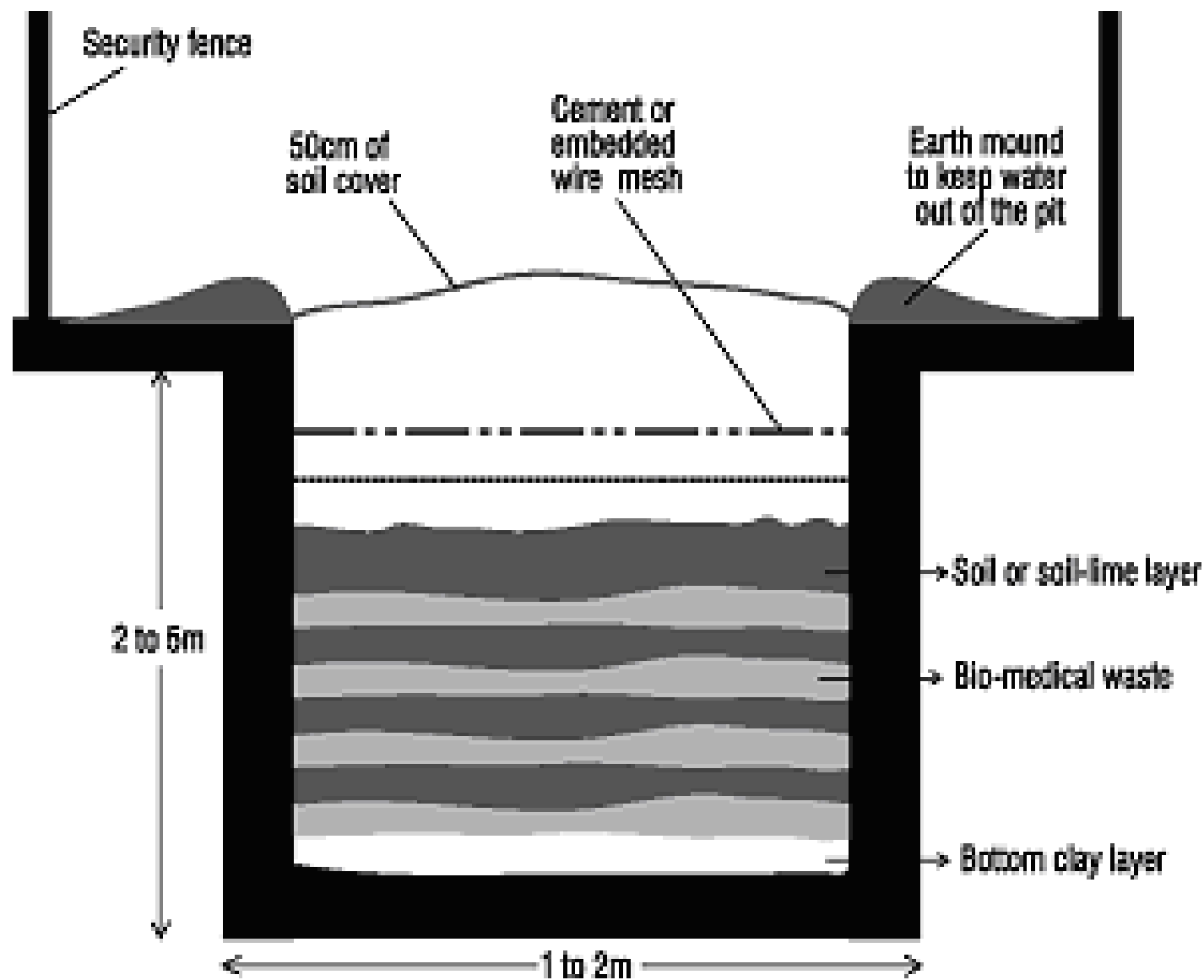
Waste Burial (contd.)

- **Wastes to be buried and should not be incinerated**
- Used infectious plastic syringes and needles
- Other infectious PVC plastics such as tubing, catheters, IV sets.
- All these should be buried in a sharps waste burial pit.

Process of waste burial:

- Dig a pit 1 to 2 meters wide and 2 to 5 meters deep.
- Line the bottom of the pit with clay or low permeable material.
- Construct an earth mound round the mouth to prevent water from entering.
- Construct a fence around to prevent unauthorized entry.
- Alternatively place layers of waste inside and 10 cm of lime and soil.
- When the pit is within about 50 cm of the ground surface, cover the waste with soil and permanently seal it with cement or embedded wire mesh.

Waste Burial (contd.)



- Access to authorized person only.
- Supervision by landfill staff and thus prevent scavenging.
- prevent water deposition, lined with a material of low permeability, such as clay, to prevent pollution of ground water.
- Large quantities (higher than 1 kg) of chemical/pharmaceutical wastes should not be buried.
- The burial site should be managed as a landfill, with each layer of waste covered with a layer of earth to prevent from rodents and insects and odor as well.
- Avoid flood prone areas.
- Fence with warning signs.
- The location of waste burial pit should be down-hill or down-gradient from any nearby wells and about 50 meters away from any water body such as rivers or lakes.
- HCF should keep a record of the size and location of the existing burial pits to prevent construction works.

- **Septic/concrete vault**

- for the disposal of used sharps and syringes
- Pit size: 1m x 1m x 1.8m depth without reaching the ground water level.
- The site must be isolated and at least 500 feet away from the ground water sources and dwelling units.
- Concrete walls and slabs with manhole and a security fence around.

Waste Burial (contd.)

Advantages:

- Simple
- Adequate for small quantities of waste
- No atmospheric pollution (non burn technique)
- Low construction cost

Disadvantages:

- Requires space available
- Does not disinfect waste
- Might be a risk to community if not properly buried
- Potentially easy access to non-authorized personnel
- May fill up quickly
- Potential soil and water pollution

Cemented sharp pit

Pit well covered with a narrow access for sharps. Should be filled with cement once full.

- Needles: 1 million in 1m³
- Needle + syringes: 30,000 in 1m³

Advantages

- Low cost
- Simple
- Adequate for large quantities of needles
- No atmospheric pollution (non burn technique)

Disadvantages

- Space availability
- Does not disinfect waste
- No volume reduction

Sanitary Landfill

- Wastes are disposed of in the ground at a landfill site.
- Landfills are specifically designed and engineered to prevent wastes from contaminating the environment.
 - Easy access, Effective controlling the daily operation.
 - Adequate Lining to minimize the movement of waste water.
 - Gas control measures, environmental monitoring points and bore holes (for monitoring air and ground water quality).
 - Adequate and efficient mechanism of leachate collection and treatment.
 - The site must be well organized in a small area, i.e. proper preading, compaction, and daily covering the waste with soil.
 - Protected with wire bar/fence to prevent from unauthorized persons, animals and birds.
 - Prevent/minimize rain water infiltration when each phase of the landfill is completed.
 - Needs a secured transport to landfill site, especially if the waste is still infectious or not encapsulated

Medical Waste Management in Nepal

- **GEF-SGP**
- 274 hospitals generate 10,520 tonnes of non-hazardous healthcare waste per year and 3,094 tonnes of hazardous medical waste (Government of Nepal, 2014).
- The waste was disposed of as regular city garbage, which presented a problem for municipal waste collectors. It was also burnt in incinerators which released persistent organic pollutants (POPs) such as dioxin to the environment.
- (MoH, 2003) HCW generation is 1.7 Kg/person/day. Out of the generated waste of HCFs, 26 % of the waste is hazardous.
- (UNEP, 2012)-0.533 kg/bed day.
 - 0.256 kg/bed-day is general, non-hazardous, and non-biodegradable waste,
 - 0.147 kg/bed-day is biodegradable waste,
 - 0.120 kg/bed-day is infectious waste including sharps; and
 - 0.009 kg/bed-day is hazardous chemical/pharmaceutical waste.

- International Agreements:
 - Basel convention 1989: Environmentally Sound Management-“Integrated Life-Cycle Approach”
 - The Stockholm convention on persistent organic pollutants 2001-
 - Accumulate in the fatty tissue
 - Tort law and principles
 - a. Duty of care, b. Polluter pays, c. Precautionary, d. Proximity
- (c) When the magnitude of a particular risk is uncertain, it should be assumed that this risk is significant, and the measures to protect health and safety should be designed accordingly. Following this principle one must always assume that waste is hazardous until it is proved to be safe. This means that where it is unknown what the hazard may be, it is important to take all the necessary precautions
- (d) treatment and disposal of hazardous waste take place at the closest possible location to its source to minimize the risks involved in its transport

- **Solid Waste Management Act of 2011;**
Medical waste means the hazardous waste produced and discharged from hospitals, clinics, pharmacies, dispensaries, blood banks, pathology laboratories, veterinary institutions and health research centers.
- The town development act 1989: Town Development Committee to regulate, control or prohibit to do any act and activity which causes adverse effect on natural beauty, tourism site and public health or which causes environmental pollution
- The local self-governance act 1999: empowered the local body to fine anyone up to Rs.15,000 for haphazard dumping of solid waste.
- EPA 2019/EPR 2020
- Solid Waste Management Regulation 2013
- Health Care Waste Management Guidelines, 2014 (Ministry of Health and Population Department of Health Services)
- Guideline for health institutions establishment, operation and upgrade standard 2070

- **Other Measures**

- UN Minamata Convention on Mercury, adopted on October 2013 in Japan
- Second Long Term Health Plan 1997-2017
- Nepal Health Sector Program Implementation Plan 2010-2015
- National Guidelines on Clinical Trials with the use of Pharmaceutical Products 2005
- Standards for medical college and hospital as per the Ministry of Health and Population (MoHP) and Medical Council
- Standards of Medical College as per the university to be affiliated

Standards

- Waste water/effluent standards 2060
- National Drinking Water Quality Standard 2062
- National air quality standard 2069
- NAAQS

- Solid waste management policy 1996
- The industrial enterprises act 1992
- The labour act 1992

- MoHP/ WHO (MoHP, 2012) concluded that the waste management system is poor and 38.7% hospitals adopted correct segregation of HCWs.
- Western region of Nepal (DoHS, 2013), 70% of clinical staff and 63% of non-clinical staff reported a needle stick injury (NSI) or other sharps injury at some time.

- UNEP/SBC/WHO, 2004 Categories of HCW
 - Non-risk HCW
 - HCW requiring special attention
 - Infectious and highly infectious waste
 - Other hazardous waste
 - Radioactive waste
- HCW (WHO, 1999): 20% hazardous and 80% general wastes.

BENEFITS of HCWM

- Protection of public health by reducing the exposure of employees, patients, attendants, and entire community to hazardous HCWs in the work environment
- Facilitate compliance with regulatory requirements
- Enhance community relation by demonstrating a commitment to environmental protection
- Reduce waste handling and disposal volumes along with costs without compromising the quality of health care
- Increase employee morale resulting from a healthier and safer working environment

Categorization of HCW based on the UNEP/SBC/WHO

- **Non-risk**

- Administrative and house-keeping services
 - Office waste, garden/yard waste, packaging or left over food
- Recyclable, Biodegradable, and Other

- **Waste requiring special attention**

- **human anatomical waste:** tissue waste, removed organs, amputated body parts, placentas, blood, body fluids, human fetus, animal and carcasses obtained through medical procedures.
- **sharp waste:** needles, broken glass ware, ampoules, scalpel blades, lancets, cover slips, glass slides, vials without content, various plastic items such as amniotic membrane perforators and broken plastic pipettes.
- **pharmaceutical waste:** (i): **Non-hazardous**-camomile tea, normal saline, dextrin or cough syrup, (ii) **Potentially hazardous; and (iii) Hazardous**
- **Cytotoxic pharmaceutical waste:** alkylated substances, antimetabolites, antibiotics, plant alkaloids, hormones
- Blood and body fluids: dressing material, swabs, syringes without needle, infusion equipment without spike, bandages contaminated with human or animal blood, secretions and excretions

- Infectious and highly infectious waste:
Contaminated with Pathogens

- Infectious- Blood from patients contaminated with HIV, viral hepatitis, brucellosis, Q fever, feces from patients infected with typhoid fever, enteritis, cholera and respiratory tract secretions from patients infected with TB, anthrax, rabies, poliomyelitis are also considered as infectious waste.
- Highly infectious waste- sputum cultures of TB laboratories

- Other hazardous waste

- Toxic, Corrosive (pH 2-12), Flammable, Reactive, (explosive, water-reactive, shock sensitive), Cytotoxic or genotoxic properties
- used and disposed of according to the specifications provided with each type of chemical
- thermometers, blood-pressure gauges, photographic fixing and developing solutions in X-ray departments, halogenated or non-halogenated solvents, organic and in-organic chemicals, containers or aerosol cans with pressurized liquids, gas or powdered materials

- Radioactive waste

Reading Materials

- https://climate.mohp.gov.np/downloads/Health_Care_Waste_Management_Guideline_2071.pdf
- <https://www.hospitalesporlasaludambiental.net/wp-content/uploads/2016/07/Leadership-and-Waste-Health-Care-Waste-Management-System-in-Nepal-Bir-Nepal.pdf>

What is Special about Special Waste

Special Wastes

- Waste from a business that requires additional or specific handling for proper disposal;
- Garbage, refuse, or other discarded material or waste, including solid and semi-solid materials that require a special administrative assessment, additional processing, special transportation, special packaging, and/or additional disposal techniques due to the quantity of material generated and/or its unique physical, chemical, or biological characteristics.
- Examples of common special wastes include petroleum-contaminated soil, asbestos, stabilized grit & bar screenings, absorbent booms, and pads, liquids, pit sludge, baghouse dusts, dried paint filters, biosolids, grease/scum waste, or any other hard-to-handle material that is not considered hazardous.

Special Wastes

- Nonresidential or commercial solid wastes, other than regulated hazardous wastes, that are either difficult or dangerous to handle and require unusual management at municipal solid waste landfills, including, but not limited to:
 - (1) Pesticide wastes;
 - (2) Liquid wastes and bulk liquid wastes;
 - (3) Sludges;
 - (4) Industrial process wastes, defined as wastes generated as a direct or indirect result of the manufacture of a product or the performance of a service, including, but not limited to, spent pickling liquors, cutting oils, chemical catalysts, distillation bottoms, etching acids, equipment cleanings, point sludges, core sands, metallic dust sweepings, asbestos dust, and off-specification, contaminated, or recalled wholesale or retail products. Specifically excluded are uncontaminated packaging materials, uncontaminated machinery components, landscape waste, and construction or demolition debris;

Special Wastes

- (5) Wastes from a pollution control process;
- (6) Residue or debris from the cleanup of a spill or release of chemical substances, commercial products, or wastes listed in items (1) through (5);
- (7) Soil, water, residue, debris, or articles that are contaminated from the cleanup of a facility or site formerly used for the generation, storage, treatment, recycling, reclamation, or disposal of wastes listed in items (1) through (6); and
- (8) Containers and drums.

Categories of special waste

- **Commercial/Industrial Waste:** This is non-hazardous industrial process waste, treated infectious waste and similar potentially harmful waste that requires special handling. Examples include: processed sludge, ash, filters, sandblast media and dusty wastes. Commercial/industrial waste must not contain "free" liquids and must be containerized if it can become airborne.
- **Liquid/Semi-solid waste:** These wastes are mixed with absorbent materials to allow for beneficial use and proper disposal in the landfill. Examples include industrial liquids, cooling fluids, cutting oils, rinse water, latex paints and inks, food production waste, municipal waste, tank bottoms/sludges, and drilling waste.
- **Petroleum Contaminated Soils:** These soils are non-hazardous and contaminated with petroleum products. This type of waste is treated by aeration and then used as a daily cover at the [Landfill](#).
- **Other Special Waste:** These need special handling, such as spill cleanup materials, off-spec products, animal carcasses, drums and pressurized containers, fluorescent lights, and [asbestos](#).

Characterization and Management

- Require special or extraordinary handling conditions due to the characteristics of the wastes or additional regulatory controls on the management of the wastes.
- Certified knowledge of the process by which the waste stream was generated
- Analytical test data/Profiling
- Application for permits
- Permits
- Waste Tracking
- Certified Disposal

Management of Special Waste

- Animal Wastes: Dead Animal, Caracass, Poultry Litter
- Automotive Waste: Tire, Used Oil, Lead Acid Battery
- Construction and Demolition Waste: Debris, wood, Fluorescent Lamp, Paints
- Waste water/Sewage/sludges, Containers

E-Waste



E-Waste

- The electronic industry is the world's largest and fastest growing manufacturing industry.
- Rapid product obsolescence and technological advances are a new environmental challenge
- Socio-economic development and technological advancement are the main drivers of increasing trend of E-waste.
- Latest cellular phones, laptops, air conditioners and consumer electronics.
- Problem in Management, Inadequate legislation, difficulty in inventory, health hazards due to informal recycling, poor awareness and reluctance on part of the corporate to address the critical issues.
- When economically valuable materials are dumped resources are wasted

E-Waste

- Electronic waste, e-waste, e-scrap, or [Waste Electrical and Electronic Equipment \(WEEE\)](#) describes discarded electrical or electronic devices.
- Discarded computers, office electronic equipment, Entertainment device electronics, mobile phones, television sets and refrigerators which are made of sophisticated blends of plastics, metals, and other materials.
- Used electronics which are destined for reuse, resale, salvage, recycling and disposal.
- According to Gui et al (2003), "WEEE is diverse and complex in terms of materials and components as well as the manufacturing process. Characterization of this waste stream is of paramount importance for developing a cost effective and environmental friendly recycling system".
- The European [WEEE Directive](#) classifies waste in ten categories:

(1) Large household appliances (including cooling and freezing appliances)

(2) IT equipment including monitors

(3) Lamps and Luminaires

(4) Tools

(5) Automatic dispensers

(6) Small household appliances

(7) Consumer electronics (including TVs)

(8) Toys

(9) Medical devices

(10) Monitoring and control instruments

E-Waste

- The Partnership on Measuring ICT for Development defines e-waste into six (6) categories, namely :
 - (1)Temperature exchange equipment (e.g., air conditioners, freezers),
 - (2)Screens, monitors (e.g., TV, laptop),
 - (3)Lamps(e.g., LED lamps),
 - (4)Large equipment (e.g., washing machines, electric stoves),
 - (5)Small equipment (e.g., microwave, electric shaver), and
 - (6)Small IT and telecommunication equipment (e.g., mobile phones, printers).
- Products in each category vary in longevity profile, impact, and collection methods, among other differences

E-Waste-Constituents

- E-waste constitutes heavy metals, persistent organic pollutants, flame retardants and other potentially hazardous substances.
- Large and small household appliances, electrical and electronic toys and sporting equipment, tools, computers and related equipment etc. contains metallic and non metallic elements, alloys and compounds such as Cu, Al, Au, Ag, Palladium, Platinum, Ni, Tin, Pb, Fe, S, P, As etc. The fraction includes over 60% of metals, while plastics account for about 30% and the hazardous pollutants comprise only about 2.70%.

E-Waste-Constituents

- During recycling and material recovery **three main groups of substances are released into the environment** which needs high priority attention as they are highly hazardous in nature.
- **The first group** is the original constituents of equipment such as Pb and Hg. Improper breaking or burning of printed circuit boards and switches may lead to the release of Hg, Cd and Be. About 70% of the heavy metals especially Hg & Cd, in landfills come from electronic waste.
- **Second group** such as cyanide, added during some recovery processes
- **Third group** which are formed during recycling processes such as **dioxins and furans**. recycling of components containing hazardous compounds such as halogenated chlorides and bromides used as flame-retardants in plastic, which form persistent dioxins and furans on combustion at low temperatures.

E-Waste Generation

- 44.7 million tonnes generated in 2016
- In 2019, the world generated **53.6 million metric tons (Mt)**, and only 17.4% of this was officially documented as properly collected and recycled.
- Most importantly, official data for the transboundary movement of e-waste are unknown. Most of the e-waste (i.e 16 Mt) was generated in Asia.

Management of E-Waste (4 –steps)

- ***A. Composition and Recycle Potential:*** Materials found in e-waste may be divided broadly into **six categories** as follows:
 - ☐ Iron and steel, used for casings and frames
 - ☐ Non-ferrous metals, especially Cu used in cables, and Al
 - ☐ Glass used for screens, windows
 - ☐ Plastic used as casing, in cables and for circuit boards
 - ☐ Electronic components
 - ☐ Others (rubber, wood, ceramic etc.).

Management of E-Waste

- ***B. Methodologies:*** Approach and methodology to determine the hazardousness
 - ❑ Step 1: Identification of E-waste category
 - ❑ Step 2: Identification of E-waste composition
 - ❑ Step 3: Identification of possible hazardous content
 - ❑ Step 4: Identifying whether the E-waste component is hazardous or the entire E-waste item is hazardous.

Management of E-Waste

- ***C. Recycling, Reuse and Recovery***
- *1) Dismantling*
- *2) Segregation of ferrous metal, non-ferrous metal and plastic*
- *3) Refurbishment and reuse*
- *4) Recycling/recovery of valuable materials: Ferrous metals in electrical furnaces, non-ferrous metals in smelting plants, precious metals in separating works.*
- *5) Treatment/disposal of dangerous materials and waste*

Management of E-Waste

- ***D. TREATMENT & DISPOSAL***

- ☐ land filling and incineration

E-WASTE MANAGEMENT STRATEGIES

- *A. Policy level initiatives*
- *B. Extended producer responsibility: take-back and management services for their products at the end of life of those products*
- *C. Training and awareness programmes*

Disaster Waste and Its Management

Disaster is an event and phenomena, which left behind devastating footprints with the death and destruction of lives and properties.

The left out footprint consist of physical damages to the buildings/Infrastructure and properties inside the damaged and destroyed buildings and the daily uses utilities.

After disaster, the people and government need to put its effort to manage the disaster induced waste generated by the event.

Disaster Waste and Its Management

- Disasters and conflicts can generate large quantities of solid and liquid waste that **threaten public health**, **hinder reconstruction** and **impact the environment**. Disaster Waste (DW) can be generated by the actual disaster, **as well as**, later during the response and recovery phases.
- Public health risks
 - Direct contact with waste accumulated in the streets,
 - Hazardous wastes such as asbestos, pesticides, oils and solvents,
 - Indirectly from vectors such as flies and rodents,
 - Post disaster collapse of unstable structures.

Disaster Waste and Its Management

- Relief and reconstruction efforts can be hindered when DW blocks access to affected populations and areas.
- Environmental impacts, which are closely associated with human impacts, can include waterways, agricultural areas and communities contaminated by chemicals and heavy metals. Physical obstruction of waterways can also occur. In most cases, DW places more burdens on communities already struggling to cope with catastrophe.

Disaster Waste and Its Management

- DW also presents opportunities: it may contain valuable material such as concrete, steel, and timber as well as organics for composting. This value can be realized as either a source of income or as a reconstruction material, and reduce burdens on natural resources that might otherwise be harvested for reconstruction.
- Safe handling, removal and management of DW are therefore important issues in disaster response and recovery.
- Effective approaches can help manage DW risks to life and health and seize opportunities from the waste to support recovery and development outcomes.

Disaster Waste and Its Management

- Current DW management practice involves either
 - No action, in which the waste is left to accumulate and decompose,
 - Improper action, in which the waste is removed and dumped in an uncontrolled manner. Improper dumping may create long-term environmental problems that affect the community or occur on economically significant land and require the waste to be moved again, creating additional costs.
- National authorities have the primary responsibility for dealing with DW, when overwhelmed by a disaster it is unclear which international assistance agency can provide which type of assistance to them.

Common examples of Disaster Waste

- Concrete, steel, wood, clay and tar elements from damaged buildings and infrastructures;
- Household furnishings; parts from the power and telephone grids such as electrical poles, wire, electronic equipment, transformers;
- Parts from water and sewage distribution systems;
- Natural debris such as clay, mud, trees, branches, bushes, palm tree leaves;
- Chemicals, dyes and other raw materials from industries and workshops;
- Waste from relief operations;
- Damaged boats, cars, buses, bicycles;
- Unexploded ordnance (e.g. landmines);
- Waste from disaster settlements and camps including food waste, packaging materials, excreta and other wastes from relief supplies;
- Pesticides and fertilizers;
- Household cleaners;
- Paint, varnish and solvents; and
- Healthcare waste.

Disaster Waste and Its Management

- Human corpses, animal carcasses, faecal material and urine disposed of in functioning latrines or contaminated land.

Typical disaster waste issues and their impacts

Issue	Typical human and environmental impacts
Uncollected building rubble from damaged buildings	Impeded access and constrained rehabilitation & reconstruction activities. Waste tends to attract more waste since the site is already considered a dumping site.
Dumping in inappropriate areas and/or proliferation of scattered dump sites	Potential human health and injury risks from dump sites too close to settlements, especially from hazardous materials. Destruction of valuable land. Impacts on drinking water supplies and damage to valuable fisheries. Additional costs if waste must be moved later. Increase in disease vectors (flies, mosquitoes, rats, etc.). Risk of waste piles collapsing. Risk of fires. Risk of cuts from sharp materials, including used syringes.
Collapse of municipal solid waste services, including possible loss of experienced waste managers	Lack of collection service and uncontrolled dumping of waste.
Uncontrolled dumping of healthcare waste from hospitals and clinics	Serious health risks to local populations including the spread of disease and infection, for example from used syringes; odour problems.
Asbestos sheet exposure in collapsed structures or in re-use of asbestos for reconstruction	Health risks associated with inhalation.

Hazard Type and Their Waste Characteristics

Earthquakes	Structures collapse 'in-situ', i.e. floor slabs collapse on top of each other, trapping waste within damaged buildings and structures. This can lead to challenges in sorting out hazardous waste (e.g. asbestos) from non-hazardous (e.g. general building rubble). Collapsed buildings may overlap across streets, making access difficult for the search and rescue and relief operations. Quantities of waste are high compared to other disaster types since all building contents normally become waste.
Flooding	Initial damage depends on the structural integrity of infrastructure, while building contents are normally damaged extensively. Mould may be present and timber may have begun to rot. Buildings are typically stripped by owners and waste placed on roads for collection. Waste is often mixed with hazardous materials such as household cleaning products and electronic goods. Flooding may bring mud, clay and gravel into affected areas, making access difficult once the floodwater recedes. Removal may be required for relief and recovery operations. The mud, clay and gravel may be mixed with hazardous materials, requiring further assessment before dumping.
Tsunami	Strong tsunamis can cause widespread damage to infrastructure, spreading debris over large areas. Debris is often be mixed with soils, trees, bushes and other loose objects such as vehicles. This makes waste difficult to handle and segregate.

Hazard Type and Their Waste Characteristics

Volcanoes	The damage caused by volcanic eruptions primarily results from the dispersal of ash and pumice stone in combination with flows of molten rock (lava). The removal of debris is often obstructed by fine ash particles which cause further strain on mechanical and hydraulic equipment as well as electric and electronic devices.
Hurricanes typhoons cyclones	Strong winds can tear the roof off buildings, after which walls may collapse. Poorly constructed houses and huts can 'fold' under roof tops. Even brick and concrete walls may collapse. Waste is spread over open land, streets, and marketplaces. This would include roofing materials, small items and dust carried by the wind. This may cause serious problems where asbestos is present. Ships and boats are often thrown ashore and destroyed, requiring specialized waste management. Vessels that sink in harbours need to be removed. Electrical and telephone grids as well as transformers containing oil and PCBs may be destroyed.

Hazard Type and Their Waste Characteristics

Conflict – short-term

Intense, short-term conflicts can involve rockets, missiles and bombs, which, combined with land combat, result in damage to buildings and infrastructure, key strategic installations being bombed and/or widespread damage to industrial and residential areas.

Damaged infrastructure is often burnt, resulting in the destruction of most internal furnishings and fittings. This reduces the quantities of debris to be managed and leaves primarily non-flammable items such as concrete, bricks and stones. Bridges, roadways, railway structures etc. are often targeted. Their clearing requires heavy machinery such as excavators and bulldozers.

Waste collection vehicles may be damaged or be commandeered for military purposes.

Unexploded ordnance (UXO) including undetonated landmines may be present among waste.

Conflict – protracted

Protracted conflicts share similarities with short-term, intense conflicts but there is often more widespread damage to building and infrastructure, and increased use of landmines on or near strategic roadways and facilities.

- 3 Conditions for waste to pose a risk to human health or the local
 - (1) hazardous (i.e. toxic to human health) or present a hazard;
 - (2) a route or 'pathway' by which the hazardous waste can
 - (3) impact a 'receptor', for example a person or a water source.
- Where these three elements of risk are present, the waste can have a negative impact and must be considered a potential priority.

Response and Preparedness Actions

- **Phase 1:** Immediate and short term actions: Most acute waste issues required to save lives, alleviate suffering and facilitate rescue operations. Any other considerations at this stage are secondary.

☐ ***0-72 hours: Immediate Actions***

Hazard Ranking:

Identify Waste Issues:

Geographic Location

Characterize Waste through site visit

Map Waste

Assess Waste

Prioritize Action: *Disposal Site, Access Clearance, utilization of available equipment and stakeholders, Separate storage and transport of Medical waste/health care waste to temporary special treatment or disposal sites*

Response and Preparedness Actions

☐ **72 hours onwards: Short Term Actions**

Collection of HH Waste,

A rapid DW assessment, Exact data is not required, but reasonable ideas about the status of waste management, access to disposal sites, the ability of local authorities to handle the situation, and the need for any international assistance should be provided.

- **Other Considerations:**

- Wastes from Internally Displaced Person (IDP) camps should be managed in coordination with general solid waste management services, and thus integrated with the local waste collection services.
- Ownership of waste, in particular reusable waste, is an important issue to clarify to avoid later conflicts.

Response and Preparedness Actions_Phase II

- **Phase 2: Medium Term Actions**

- Implementation of disaster waste management programme. Efforts towards building on the initial Phase 1 assessment but go into greater depth, with an emphasis on longer-term solutions.

- **Assessments**

- Continue to assess the disaster waste (extent of waste generation, locations, types of waste, regulatory understanding, etc.).
- Assess locations for medium term temporary disposal and waste separation sites for unsorted rubble and municipal waste. This may entail upgrading or improving current dumpsites.
- Assess requirements to close current dumpsites if these pose a threat to human health or the environment.
- Identify and assess other waste management facilities in or near to the disaster affected area.
- Assess local capacities for addressing disaster waste and identify gaps/needs for additional assistance.

Response and Preparedness Actions_Phase II

❑ *Operations*

- Establish temporary storage sites for debris and regular waste.
- Initiate collection and transportation of waste and debris, with the goal of expanding this in the latter phases .
- Prepare practical advice and guidance for local authorities on interim solutions to minimize environmental and health impacts of disaster waste.

Response and Preparedness Actions_Phase II

□ *Planning*

- Implement a communications plan for affected communities with a focus on opportunities (i.e. reuse and recycling), risks (i.e. human health risks) and collection schemes.
- Develop a plan for healthcare waste. This may entail the construction of a temporary incinerator for healthcare waste.
- Develop a special plan for hazardous waste (including asbestos) collection and treatment.
- Consult affected communities on issues relating to public health, wastes, livelihoods and the environment.
- Identify exit strategies and handover options for the disaster waste management systems planned for establishment.

Response and Preparedness Actions_Phase II

□ *Communication and Reporting*

- Communicate rapidly and regularly regarding all findings to the local authorities
- Document in electronic form the assessment results, recommendations, and mitigation measures implemented.

The outputs from these planning actions include data and information to design a disaster waste management programme to be implemented in the recovery phase.

Response and Preparedness Actions_Phase III

❑ Phase 3: Long Term Actions

- This Phase includes implementation of disaster waste management projects designed in Phase 2, and continued monitoring and evaluation of the disaster waste situation.
 - Develop and implement a communications plan
 - Procure or repair required waste management plant, machinery and equipment.
 - Train waste management operators if required.
 - Support the implementation of disaster waste management systems by supporting waste management operators/operatives or local authorities.
 - Hand over disaster waste management systems into a normalized and improved solid waste management system.
- The output of this phase should be having all disaster waste addressed either through disposal, incineration, reuse or recycling.

Response and Preparedness Actions_Contingency Planning

Phase 4: Contingency Planning

- It is not part of emergency response. However, it does help bridge the gap between response, recovery, and longer-term development and is therefore an important investment.
- Contingency planning can be conducted during the long term phase or as a preparedness measure prior to disaster.
- The objective is to develop a Disaster Waste Management Contingency Plan (DWMCP) to aid communities in determining appropriate management options in advance of a disaster.
- A plan identifying cost-effective disaster waste management options and resources can save money, increase control over waste management and improve administrative efficiency.
- The plan may also serve as a resource document in negotiating technical and financial assistance.

Response and Preparedness Actions_Contingency Planning

An effective DWMCP addresses issues well beyond initial removal and should include a strategy for recycling and reuse of materials (including composting). There are many possible components of a DWMCP, including:

1. Pre-planning activities;
2. Secondary activities

• Establish governmental coordination. • Identify likely waste and debris types. • Forecast amounts of waste and debris. • List applicable national, and local environmental regulations. • Inventory current capacity for waste and debris management and determine waste and debris tracking mechanisms. • Pre-select temporary waste and debris storage sites and identify opportunities for secure temporary storage of hazardous waste.	• Identify equipment and administrative needs. • Pre-negotiate contracts. • Develop a communications plan. • Create a disaster debris prevention strategy. • Create a debris removal strategy.
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Response and Preparedness Actions_Contingency Planning

3. Harmful materials identification and hazardous waste management recommendations
4. Recycling options
5. Waste-to-energy options
6. Disposal options
7. Open burning options

Case Study

- Nepal is enlisted as one of the disaster prone country in the World. It ranks 4th, 11th and 30th in terms of climate change, earthquake and flood risk.
- Landslide, fire, drought, epidemic, storm, hailstorm, avalanches and Glaciers Lake Out-burst Flood (GLOF).
- A devastating earthquake measuring in 7.8 Richter scale hit Nepal on 25 April 2015 at 11:56 AM (Local Time). Its epicenter was in Barpak, Gorkha some 77 kilometers northwest from the Kathmandu . The earthquake was preceded by a major aftershock of 7.3 magnitude on 12th May 2015.
- The earthquake in 2015 killed nearly 9000 people, injured 30,000 and destroyed 800000 buildings.
- Statistics of Nepal police up to 22nd June 2015 shows the data that 8660 people had lost their lives and 21,952 were injured .
- 7,532 schools and 1,100 health services were also damaged.

- There was huge amount of debris accumulated in earthquake affected 31 districts.
- Based on the construction practices and materials used, debris from destroyed or damaged building by a major earthquake would consists mainly of brick, stone, concrete blocks, tiles, cement concrete, steel bars, CGI sheets, wooden joist, beams, doors and window frames, steel pipes and tanks, UPVC pipes and tanks, electrical wires and cables, broken glass pieces and furniture and fixture
- Solid waste management technical support center had conducted assessment and research on volume of disaster waste, type, and characteristic of disaster waste.
- Nearly 14 million tons of waste was generated within a couple of day, four million tons of waste alone from Kathmandu, which is equal to waste generation in 11 year in normal time (PDNA 2015). This large amount of disaster related waste mixed with hazardous wastes was observed exposed to various infections, resulting in adverse impact to human health and environment (REA, MoEST, 2015).
- Disaster waste generated during 2015 Earthquake is still deposited randomly on roadsides and public places around the public places and private lands in the 14 earthquake affected districts.

Case Study

- According to PDNA, the waste produced from temporary shelters and the debris generated from destroyed houses in 14 affected districts were not in priority of any Local governmental bodies for management despite of identifying the temporary disposal sites.
- Thus, it can be clearly envisioned that disaster waste management practice in Nepal is lagging behind, as off not having appropriate policies to mobilize the skilled manpower, equipment, institutional mechanism, and financial support pre and post disaster.

Case Study

- Disaster Risk Reduction and Management Act 2017 is the one in which disaster waste is mentioned “removal of disaster generated waste” in the Clause#2 under the district disaster management committee’s roles and responsibilities.
- Similarly under the clause #20 under public and private commercial establishment roles and responsibility it was mentioned “appropriate management of waste and pollution to minimize adverse impact to people”. This clause will greatly help in management of waste generated from the industrial and commercial establishment in the post disaster situation.
- There has also been absence of knowledge about the disaster waste management, which ,needs to be addressed in the legal framework of Nepal.